Kaon Condensation in Neutron Stars

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The dense interior of neutron stars can inhibit phase transitions to new forms of strongly interacting matter. One possibility is the condensation of bosons, like the kaon, which has been discussed intensively during the last few years [1,2]. The rather strong onset of kaon condensation has been treated so far by using a Maxwell construction [3]. This ensures that only one chemical potential is the same in the two phases in equilibrium. Nevertheless, neutron stars conserve both baryon number and charge. *Both* chemical potentials must be continuous across boundaries between the two phases. Gibbs conditions *and* the two conservation laws can be satisfied simultaneously only by imposing conservation as a global constraint [4]. Consequently, charge is redistributed between regions containing the two phases at each proportion of phase so as to minimize the energy. The force that drives the redistribution is the isospin driving force, responsible for the valley of beta stability, to which the Fermi energy and the nuclear force contribute about equally.

Kaon condensation occurs when the in-medium mass of the kaon is reduced from its vacuum value to the electrochemical potential. When this happens (if it does) it is energetically favourable to change neutrons to protons and K^-. We have studied the structure and the properties of a neutron star with a kaon condensed phase using Gibbs' conditions with global charge conservation [5].

One difference between the normal and kaon condensed phase is that the nucleon effective mass is distinctly different in the two phases as seen in Fig. 1. Clearly the Kaon condensed phase is not merely a phase in which kaons are present in addition to the nucleons; the nucleons also are different because of the K–N interaction. The phases in equilibrium are charged with opposite sign, the normal phase being positive.

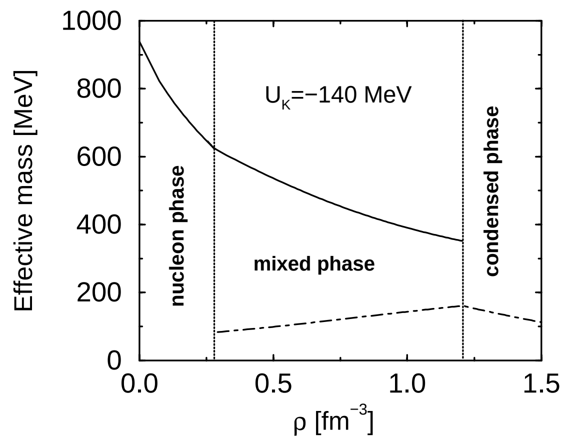

Figure 1: The effective nucleon mass in the various steps of a phase transition to kaon condensation.

Instead of a constant pressure for the mixed phase, the pressure increases with density in accord with general considerations [4]. The phase transition is much smoother compared to a Maxwell construction and resembles a second order transition. Nevertheless, Figure 1 shows that there exists a coexistence region of two distinctly different phases so that kaon condensation is of first order for a sufficiently high attractive potential in the medium.

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